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PATENT

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Applicant: Hideki KUWAJIMA et al. : Art Unit:
Serial No.: 10/684,403 : Examiner:
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FOR: PIEZOELECTRIC ACTUATOR AND DISK DRIVE USING THE SAME

VERIFICATION OF A TRANSLATION

Assistant Commissioner for Patents
Washington, D.C. 20231
SIR :

CERTIFIED COPY OF PRIORITY DOCUMENT

I, the below named translator, hereby declare that:

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2. That I am knowledgeable in the English language and in the language of JP2002-301604, and I believe the attached English translation to be a true and complete translation of JP2002-301604.

3. The document for which the attached English translation is being submitted is a patent application on an invention entitled PIEZOELECTRIC ACTUATOR AND DISK DRIVE USING THE SAME.

I hereby declare that all statements made herein of my own

knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Date: ______________________________

Katsuyuki Hirano

Full name of the Translator

K. Hirano

Signature of the Translator

c/o Matsushita Technical Information Services Co., Ltd.,
Osaka Business Park, Matsushita IMP Bldg., 18th Floor,
1-3-7, Shiromi, Chuo-ku, Osaka-shi, Osaka, 540-6318 Japan

Post Office Address

[Name of the Document] Specification

[Title of the Invention] Piezoelectric actuator and disc drive using the same

[Claims]

[Claim 1] A piezoelectric actuator comprising:

a flexible substrate separated by a slit;

a first piezoelectric element unit disposed on one of said separated flexible substrates;

a second piezoelectric element unit disposed on other of said separated flexible substrates approximately in parallel with said first piezoelectric element unit; and

a coupling portion for coupling said flexible substrates, disposed on the loop of the primary bending mode in the case where said first piezoelectric element unit and said second piezoelectric element unit are supported at both ends respectively.

[Claim 2] A piezoelectric actuator as defined in Claim 1, wherein the coupling portion is composed of a wiring material provided on the flexible substrate.

[Claim 3] A piezoelectric actuator as defined in Claim 1, wherein the coupling portion is composed of a plurality of comb-shaped coupling portions.

[Claim 4] A piezoelectric actuator as defined in Claim 2, wherein the wiring material is shared by the first piezoelectric element unit and the second piezoelectric element unit.

[Claim 5] A piezoelectric actuator as defined in Claim 2, wherein

the coupling portion is provided across the separated flexible substrates, and the thickness of said coupling portion is larger than the width of said coupling portion.

[Claim 6] A piezoelectric actuator as defined in Claim 1, wherein the first piezoelectric element unit and the second piezoelectric element unit make a displacement in directions opposite to each other.

[Claim 7] A piezoelectric actuator as defined in Claim 1, wherein the first piezoelectric element unit and the second piezoelectric element unit have a thin film piezoelectric body respectively.

[Claim 8] A piezoelectric actuator as defined in Claim 6, wherein the first piezoelectric element unit and the second piezoelectric element unit form a multilayered thin film piezoelectric body coated with a metal film on the top face and the bottom face respectively, with an adhesive layer between the two bodies.

[Claim 9] A disc drive comprising at least:

a disc, a head slider equipped with a magnetic head,a flexure for fixing said head slider,

an arm on which is fixed said flexure, and

a first positioning means and a second positioning means for positioning said head slider at prescribed position of said disc,

wherein

said first positioning means is a driving means for turning said arm,

said second positioning means is an actuator for making fine displacement of said head slider to prescribed position of said disc by means of a piezoelectric element fixed to said flexure, and

said actuator is a piezoelectric actuator as defined in either one of Claim 1 to Claim 8.

[Detailed Description of the Invention]

[0001]

[Field of the Invention]

The present invention concerns an actuator element formed with a piezoelectric material having characteristics of extending and contracting with an application of voltage, more specifically a piezoelectric actuator which is an actuator used for the head positioning mechanism of a disc drive, and a disc drive using the same.

[0002]

[Background Art]

Disc drive made a great progress, in recent years, in linear recording density along a track thanks to improvement of head element. Along with this trend, improvement of recording density in the direction perpendicular to the track has become very important, requiring realization of a finer track pitch. A mechanism enabling fine displacement of the magnetic head is required, to make the magnetic head accurately follow a track of narrow width.

[0003]

In a magnetic disc type information recording & playback system, the magnetic head for performing recording & playback of information on a magnetic disc is loaded on a head slider, and mounted on an actuator arm. Recording & playback are made with a magnetic head positioned at prescribed track position on the magnetic disc, by swinging this actuator arm

by means of a voice coil motor (abbreviated as VCM). However, with the improvement of the recording density, it is no longer possible to secure any sufficient accuracy with positioning by such conventional VCM only. For that reason, proposal is made for performing high-speed and high-accuracy positioning with a fine drive of the head slider, by means of a fine positioning means using a piezoelectric element as auxiliary actuator (see patent literature 1, for example), in addition to the positioning means by VCM. In addition, an example is disclosed using a thin film piezoelectric element, as auxiliary actuator (see patent literature 2, for example).

[0004]

(Patent literature 1)

Japanese Patent Journal No. 2529360

(Patent literature 2)

Japanese Laid-Open Patent Publication No. H9-73746

[0005]

[Problems to be Solved by the Invention]

By the way, a piezoelectric element constituting such auxiliary actuator is requested to have features such as compact size, light weight, a large amount of displacement obtained with a low applied voltage, and no mutual influences of main actuator and auxiliary actuator on their respective actions.

[0006]

The conventional example had a problem of being unable to satisfy those requirements at a time. Namely, to make the resonance frequency of the auxiliary actuator larger than that of the main actuator and increase the

amount of displacement of the piezoelectric element, it was necessary to increase the rigidity of the auxiliary actuator and apply a high voltage of tens of volt. For that reason, there were such problems as complicated construction and large-scale circuit construction, making it difficult to apply the piezoelectric element especially to disc drives in compact size.

[0007]

The objective of the present invention is to provide an actuator which is capable of solving the above-mentioned problems of the conventional construction, and producing a large amount of displacement with a low applied voltage, and is stable also against bending mode produced with extension and contraction of the auxiliary actuator, as well as a disc drive using the same.

[0008]

[Means to Solve the Problems]

To achieve this objective, the piezoelectric actuator of the present comprises a flexible substrate separated by a slit, a first piezoelectric element unit disposed on one of said separated flexible substrates, a second piezoelectric element unit disposed on other of said separated flexible substrates approximately in parallel with said first piezoelectric element unit, and a coupling portion for coupling said flexible substrates, disposed on the loop of the primary bending mode in the case where the first piezoelectric element unit and the second piezoelectric element unit are supported at both ends respectively. This construction produces an effect of reinforcing the bending mode of the piezoelectric actuator, enabling to suppress the bending resonance produced when the respective piezoelectric element units extend

and contract in directions opposite to each other.

[0009]

Moreover, the coupling portion of the piezoelectric actuator of the present invention is composed of a wiring material provided on the flexible substrate. This makes it possible to provide the coupling portion with strength for elastically supporting the actuator.

[0010]

Furthermore, since the coupling portion is composed of a plurality of comb-shaped coupling portions, the control of bending resonance can be made more accurately.

[0011]

Still more, because the wiring material is shared by the first piezoelectric element unit and the second piezoelectric element unit, this increases the effect of combining the separated flexible substrates, thus increasing the bending resonance suppressing effect.

[0012]

Yet more, because the coupling portion is provided across the separated flexible substrates, and the thickness of said coupling portion is larger than the width of said coupling portion, it becomes possible to accurately prevent occurrence of bending resonance, without preventing the respective piezoelectric element units from extending and contracting in directions opposite to each other.

[0013]

Moreover, in the piezoelectric actuator of the present invention, the first piezoelectric element unit and the second piezoelectric element unit

have a thin film piezoelectric body respectively, and form a multilayered thin film piezoelectric body coated with a metal film on the top face and the bottom face respectively, with an adhesive layer between the two bodies. This enables to realize a thin and compact piezoelectric actuator with a large amount of displacement even with a small applied voltage.

[0014]

Furthermore, the disc drive of the present invention is a disc drive comprising at least a disc, a head slider equipped with a magnetic head, a flexure for fixing said head slider, an arm on which is fixed said flexure, and a first positioning means and a second positioning means for positioning said head slider at prescribed position of said disc, wherein the first positioning means is a driving means for turning the arm, the second positioning means is an actuator for fine moving the head slider to prescribed position of the disc by means of a piezoelectric element fixed to said flexure, and the above-described piezoelectric actuator is used as actuator. This enables to realize a disc drive capable of high-speed high-accuracy positioning.

[0015]

[Description of the Preferred Embodiment]

Explanation will be given hereinafter on the piezoelectric actuator and the disc drive using the same according to the present invention, with reference to drawings.

[0016]

Fig. 1 is a perspective view of the head supporting mechanism equipped with actuator elements composed of piezoelectric actuator in a preferred embodiment of the present invention, and Fig. 2 is a perspective

view showing that head supporting mechanism in disassembled state. In addition, Fig. 3 is a perspective view of the slider used for that head supporting mechanism.

[0017]

In Fig. 1 to Fig. 3, head supporting mechanism 100 has load beam 4 for supporting, at the tip, slider 2 on which is mounted magnetic head 1. Load beam 4 has base portion 4a in square shape mounted on a head actuator arm (not illustrated), and this base portion 4a is fixed to base plate 5 by means of beam welding, etc. Base plate 5 is mounted on said head actuator arm. Load beam 4 has neck portion 4b extending from base portion 4a and getting narrower toward the tip, and beam portion 4c provided in a way to extend linearly from there. At the center of neck portion 4b is provided opening 4d, to form plate spring 4e. At the respective side edges at the tip of beam portion 4c are provided regulating portions 4f for regulating pivotal motions of slider holder 3a with a small gap against it.

[0018]

The respective regulating portions 4f extend linearly from the tip of beam portion 4c toward base portion 4a side. On beam portion 4c is provided flexure 7 having head wiring pattern 6, as shown in Fig. 2. Flexure 7 is basically made of a stainless steel material. On slider mounting portion 7x disposed at one end of flexure 7 is provided slider 2 loaded with magnetic head 1. In addition, flexure 7 is provided with thin film holders 8a, 8b, and piezoelectric actuator element 10 is placed on those thin film holders 8a, 8b.

[0019]

As shown in Fig. 3, four terminals 2a ~ 2d are disposed in parallel, at the bottom part of the end face on which is provided magnetic head 1 of slider 2. Moreover, on the top face of slider 2 is provided air bearing surface 2e forming an air lubricating film against the magnetic disc, by circulating the air current produced by a rotatively driven magnetic disc (not illustrated) along the direction of pitch of slider 2 (tangential direction of the magnetic disc). The center position of air bearing surface 2e agrees with dimple 4g of load beam 4.

[0020]

Fig. 4 is a perspective view of showing the tip part on which to load slider 2 of flexure 7 in head supporting mechanism 100. In Fig. 4, flexure 7 is composed of flexure substrate 3 mainly made of a stainless steel material constituting the main body of flexure 7, slider holding substrate 3a and flexible substrate 8c formed with a resin such as polyimide, etc., for example. Flexure substrate 3, slider holding substrate 3a and flexible substrate 8c are bonded to one another on their faces. Therefore, flexure substrate 3 and slider holding substrate 3a are connected to each other by means of this flexible substrate 8c. Furthermore, on flexible substrate 8c are provided hinge portions 19a, 19b which are elastic hinge portions formed locally with a narrow width. Hinge portions 19a, 19b are provided at the boundary between flexure substrate 3 and slider holding substrate 3a, and flexure substrate 3 and slider holding substrate 3a are connected movably to each other by means of these hinge portions 19a, 19b . Wirings 6a, 6b, 6c, 6d are provided on slider mounting portion 7x of flexible substrate 8c. Moreover, on the top face of flexible substrate 8c are provided thin film holders 8a, 8b

separately from each other across slit 30 in a state parallel to each other, and around thin film holders 8a, 8b are further provided wirings 6a, 6b, 6c, 6d in extension. Furthermore, around slit 30 is provided ground wiring 9d for grounding electrode of piezoelectric actuator element 10, and part of slit 30 is connected there by means of flexible substrate 8c, to form coupling portion 40. Still more, on flexible substrate 8c of coupling portion 40, ground wiring 9d disposed around slit 30 is formed in a way to short-circuit both sides of slit 30. On slider holding substrate 3a is in contact with dimple 4g formed near the tip of load beam 4. This projection 3b is pressed by dimple 4g, and slider holding substrate 3a is rotatively held in all directions around dimple 4g. Therefore, both ends of film holders 8a, 8b are supported by flexure substrate 3 and slider holding substrate 3a.

[0021]

Yet more, as shown in Fig. 2, at other end of flexure 7 is provided external connecting terminal holder 7y. External connecting terminal holder 7y is disposed at the side edge in the direction opposite to neck portion 4b at base portion 4a of load beam 4.

[0022]

Fig. 5 is a partial expanded perspective view showing a detailed construction of coupling portion 40. Fig. 6 is a sectional view A-A of flexible substrate 8c in Fig. 4, while Fig. 7 is a sectional view B-B of flexible substrate 8c in Fig. 4. As shown in Fig. 5, slit 30 is provided in flexible substrate 8c, and coupling portion 40 to which flexible substrate 8c of is partially connected is provided, in a way to couple thin film holders 8a and 8b on which is loaded piezoelectric actuator element 10. The position where

coupling portion 40 is provided is about the center in the longitudinal direction for extension and contraction of piezoelectric actuator element 10. Moreover, on flexible substrate 8c of coupling portion 40 is formed wiring coupling portion 41 in a state in which ground wirings 9d provided on both sides of slit 30 are short-circuited with each other. This wiring coupling portion 41 is constructed in such a way that its width t and thickness h may be in the relation of h > t. As shown by sectional view A-A in Fig. 6, on both sides of flexible substrate 8c are formed wirings 6a, 6b, 6c, 6d in two pieces each by the method of plating, etc. to perform wiring to head 1 of slider 2, for construction. Furthermore, at the center of flexible substrate 8c is provided slit 30, and both sides of slit 30 are formed ground wirings 9d by a similar method. On the other hand, as shown in Fig. 7 which is a sectional view including coupling portion 40, wiring coupling portion 41 is provided at coupling portion 40 by ground wiring 9d, and connected with ground wirings 9d on both sides.

[0023]

Next, explanation will be made on piezoelectric actuator element 10 formed with thin film piezoelectric body in a preferred embodiment of the present invention. Fig. 8 is a plan view of piezoelectric actuator element 10 to be loaded on thin film holders 8a, 8b in head supporting mechanism 100. Piezoelectric actuator element 10 is composed of first piezoelectric element unit 10a and second piezoelectric element unit 10b, which are both formed with thin film piezoelectric body and disposed in mirror-surface symmetry respectively. Entire piezoelectric actuator element 10 is covered with flexible coating resin 14 and, at one end of piezoelectric actuator element 10,

first piezoelectric element unit 10a and second piezoelectric element unit 10b are connected to each other with this coating resin 14 at connector 14a. Fig. 9 is a sectional view C-C in Fig. 8. Piezoelectric actuator element 10 is mounted by bonding on thin film holders 8a and 8b (see Fig. 4) of flexible substrate 8c constituting flexure 7. As shown in Fig. 9, piezoelectric actuator element 10 is composed of a pair of first piezoelectric element unit 10a and second piezoelectric element unit 10b provided separately on the left and on the right sides. First piezoelectric actuator element 10a and second piezoelectric actuator element 10b have a double-layer structure in which first thin film piezoelectric body 11a and second thin film piezoelectric body 11b are disposed one upon another. First electrode metal film 12a is formed on the upper side of first thin film piezoelectric body 11a as seen in the drawing, and second electrode metal film 12b is formed on the lower side. Similarly, second thin film piezoelectric body 11b is disposed below first thin film piezoelectric body 11a, and on both faces of second thin film piezoelectric body 11b are provided third electrode metal film 12c and fourth electrode metal film 12d. Second electrode metal film 12b and third electrode metal film 12c are bonded by means of adhesive 13. As described above, a large amount of displacement against applied voltage is secured by adoption of a construction in which two layers of thin film piezoelectric body are disposed in a single piezoelectric element unit.

[0024]

Fig. 10 shows flexure 7 on which is pasted piezoelectric actuator element 10 in a plan view as seen from the side on which a slider (not illustrated) is pasted, in head supporting mechanism 100 a preferred

embodiment of the present invention. Fig. 11 is a sectional view Y-Y in Fig. 10, showing details of the wiring of piezoelectric actuator element 10.

[0025]

Explanation will be made on the wirings of piezoelectric actuator element 10 in a preferred embodiment of the present invention, with reference to Fig. 11. A plus voltage is applied to first electrode metal film 12a and fourth electrode metal film 12d of piezoelectric actuator element 10, while second electrode metal film 12b and third electrode metal film 12c are stepped down to the ground level. First electrode metal film 12a and fourth electrode metal film 12d are connected, by means of bonded wire 16, to thin film piezoelectric element driving wires 9a, 9b disposed at about the middle part of flexure 7 respectively. Second electrode metal film 12b and third electrode metal film 12c are connected to thin film piezoelectric element driving wire 9c through grounding metal film 17. Grounding wire 9d of the slider, which is a grounding terminal of the slider, is short-circuited to thin film piezoelectric element driving wire 9c. Those thin film piezoelectric element driving wires 9a, 9b, 9c are connected to an external drive circuit (not illustrated), through terminals provided on external connecting terminal holder 7y.

[0026]

Next, explanation will be made on the actions of such head supporting mechanism 100, with reference to Fig. 12 to Fig. 14. Fig. 12 is a side view of head supporting mechanism 100 in a preferred embodiment of the present invention, while Fig. 13 is a drawing explaining the section of piezoelectric actuator element 10 for explaining the actions of such head

supporting mechanism 100, and the voltage application specifications. Fig. 14 is an approximate construction drawing for explaining the actions of head supporting mechanism 100.

[0027]

Thin film piezoelectric element driving wire 9c of piezoelectric actuator element 10 is set at the ground level as shown in Fig. 13 (a). To thin film piezoelectric element driving wires 9a, 9b is applied a driving voltage for driving first thin film piezoelectric body 11a and second thin film piezoelectric body 11b respectively as shown in Fig. 13 (b), (c) respectively. These driving voltages are in opposite phase to each other with reference to bias voltage Vo. As driving voltages are applied, first thin film piezoelectric body 11a and second thin film piezoelectric body 11b shrink in the direction of arrow mark B as shown in Fig. 13 (a). Because the voltages are applied to first thin film piezoelectric body 11a and second thin film piezoelectric body 11b in the polarizing direction, the polarizations of first thin film piezoelectric body 11a and second thin film piezoelectric body 11b arereversed, and therefore do not lose their properties. Moreover, in the case where the applied voltage is sufficiently small for not reversing the polarizations, either a plus or minus voltage may be applied to thin film piezoelectric element driving wires 9a, 9b, because there is no fear of spoiling their properties.

[0028]

Fig. 14 is a drawing showing rotating motions of slider 2 at the time when second piezoelectric element unit 10b extends and first piezoelectric element unit 10a shrinks. If second piezoelectric element unit 10b extends

in the direction of arrow mark E and first piezoelectric element unit 10a shrinks in the direction of arrow mark D, slider 2 and slider holder 3a turn in the direction of arrow mark C centering around dimple 4g which is in contact with projection 3b. In this way, magnetic head 1 provided on slider 2 moves in the direction of width of the respective tracks which are provided concentrically on the magnetic disc. This makes it possible for magnetic head 1, which is out of alignment from the track, to follow the prescribed track, to realize an "on-track property" with high accuracy. To slider 2 is applied a load in the order of 20 mN to 30 mN by plate spring 4e of load beam 4 indicated in Fig. 2, and this load acts on dimple 4g and slider holder 3a, when slider holder 3a is turned. Therefore, a frictional force determined by a friction coefficient between slider holder 3a and dimple 4g acts on slider holder 3a. This frictional force prevents occurrence of any out-of-alignment between projection 3b of slider holder 3a and dimple 4g.

[0029]

Fig. 15 (a) and Fig. 16 (a) schematically indicate fundamental vibration modes of such piezoelectric actuator supported and fixed at both ends, while Fig. 15 (b) and Fig. 16 (b) show the frequency response characteristics in that case.

[0030]

Fig. 15 indicates a state in which first piezoelectric element unit 10a and second piezoelectric element unit 10b are free, i.e. a case of the conventional construction in which no coupling portion 40 is provided on flexible substrate 8c on which is loaded piezoelectric actuator element 10, unlike the preferred embodiment of the present invention. Such

construction produces vibration phenomena of primary bending mode in which first piezoelectric element unit 10a and second piezoelectric element unit 10b are bent as shown with arrow marks A, B respectively, i.e. one piezoelectric element unit is bent upward while the other piezoelectric element unit is bent downward to wave, as fundamental vibration mode, with extension/contraction of piezoelectric element units. For that reason, a phenomenon of instability due to resonance of actuator elements is produced at low frequencies as shown in part C of Fig. 15 (b). If such resonance is produced, in the case where there is a difference of neutral axis position of rigid body, at the tip portion of flexure 7 in head supporting mechanism 100 in Fig. 4, between the area in which first piezoelectric element unit 10a and second piezoelectric element unit 10b are provided and the area without piezoelectric element unit on slider 2 side, losses are generated in displacements produced, making it impossible to achieve any positioning of high accuracy.

[0031]

On the other and, Fig. 16 (a) schematically indicates the fundamental vibration mode of piezoelectric actuator in the case where coupling portion 40 is provided on flexible substrate 8c on which is loaded piezoelectric actuator element 10 which is a preferred embodiment of the present invention, while Fig. 16 (b) shows the frequency response characteristics in that case. The position where coupling portion 40 is provided is about the center in the longitudinal direction of first piezoelectric element unit 10a and second piezoelectric element unit 10b, preferably the position of loop of the primary bending mode where said waving resonance is produced. From Fig.

16, it can be seen that, by providing coupling portion 40, it becomes possible to control the phenomena of waving vibrations and suppress the resonance phenomena in low-frequency areas, thus realizing high frequency response characteristics. Consequently, extension and contraction of piezoelectric element units are made on one same plane, and no losses and out-of-alignment in displacements due to extension and contraction are produced, enabling stable motions with high accuracy.

[0032]

Coupling portion 40 must have a rigidity not so much as to resist to extension/contraction of piezoelectric element units 10a, 10b in opposite directions, but sufficient for suppressing fundamental vibrations of bending mode. In this preferred embodiment, on flexible substrate 8c of coupling portion 40 is formed, as shown in Fig. 5, wiring coupling portion 41 in a state in which ground wirings 9d provided on both sides of slit 30 are short-circuited with each other, and this wiring coupling portion 41 is constructed in such a way that its width t and thickness h may be in the relation of $h > t$. For that reason, it becomes possible to increase the rigidity of wiring coupling portion 41 in the direction of thickness and decrease the rigidity in the longitudinal direction of first piezoelectric element unit 10a and second piezoelectric element unit 10b, thus enabling to realize stable motions, without preventing the phenomena of extension/contraction of the piezoelectric elements while suppressing the phenomena of waving resonance.

[0033]

Moreover, Fig. 17, indicating other preferred embodiment of coupling

portion 40, is a plan view of flexure 7 on which is pasted piezoelectric actuator element 10 as seen from the side on which a slider is pasted in the same way as in Fig. 10, and shows a case where coupling portion 40 is constructed in the shape of comb teeth with a plurality of coupling portions. By providing a plurality of coupling portions, it becomes possible to optimize the strength and flexibility of the coupling portion.

[0034]

Fig. 18 indicates the disc drive in a preferred embodiment of the present invention. Disc 50 is mounted on spindle 51, and is rotatively driven by a driving means (not illustrated) directly connected to this spindle 51. As this driving means, a spindle motor may be used, for example. Head actuator 52 comprises head slider 53 equipped with a magnetic head (not illustrated) supported and fixed at one end of flexure 54, while flexure 54 is further supported and fixed on arm 55. Arm 55 is swingably mounted on bearing 56, and on other end side of flexure 54 is disposed swinging means 57 which is the first positioning means. As swinging means 57, a voice coil motor having flat coil 58 is used, to swing arm 55 on the surface of disc 50 as shown with arrow mark 59 so as to position head slider 53 on the track of disc 50 and follow it with a magnetic head. Furthermore, in this preferred embodiment, head actuator 52 as second positioning means for fine positioning head slider 53 has a construction as indicated in Fig. 1 to Fig. 11

[0035]

For the reason, it becomes possible to perform fine positioning with high accuracy, enabling to realize a compact disc drive with a large recording capacity.

[0036]

[Advantages of the Invention]

As explained above, the piezoelectric actuator in the preferred embodiment of the present invention comprises a first piezoelectric element unit and second piezoelectric element unit displaced with extension/ contraction by application of voltage, and a coupling portion for coupling the first piezoelectric element unit and second piezoelectric element unit, at the position of the loop of the primary bending mode of the first piezoelectric element unit and the second piezoelectric element unit respectively. This construction produces an effect of reinforcing the bending mode of the piezoelectric actuator, making it possible to suppress bending resonance, in the case where the first piezoelectric element unit and the second piezoelectric element unit are displaced in directions opposite to each other.

[0037]

As a result, it becomes possible to realize a piezoelectric actuator having high frequency response characteristics and capable of high-accuracy positioning, and to supply a compact disc drive with a large recording capacity using the same.

[Brief Description of the Drawings]

Fig. 1 is a perspective view of the head supporting mechanism in a preferred embodiment of the present invention.

Fig. 2 is an exploded perspective view of the head supporting mechanism in a preferred embodiment of the present invention.

Fig. 3 is a perspective view of the slider used for the head supporting mechanism in a preferred embodiment of the present invention.

Fig. 4 is an exploded perspective view of the flexure used for the head supporting mechanism in a preferred embodiment of the present invention.

Fig. 5 is a partial expanded perspective view showing a detailed construction of the coupling portion in a preferred embodiment of the present invention.

Fig. 6 is a sectional view A-A in Fig. 4.

Fig. 7 is a sectional view B-B in Fig. 4.

Fig. 8 is a plan view of piezoelectric actuator in a preferred embodiment of the present invention.

Fig. 9 is a sectional view C-C in Fig. 8.

Fig. 10 is a plan view of the flexure on which is pasted piezoelectric actuator elements in a preferred embodiment of the present invention.

Fig. 11 is a sectional view Y-Y in Fig. 10.

Fig. 12 is a side view of the head supporting mechanism in a preferred embodiment of the present invention.

Fig. 13 (a) is a sectional view of the piezoelectric actuator in a preferred embodiment of the present invention.

Fig. 13 (b) is a pattern chart of applied voltage to terminal 9a.

Fig. 13 (c) is a pattern chart of applied voltage to terminal 9b.

Fig. 14 is an approximate construction drawing showing the rotational actions of the head supporting mechanism in a preferred embodiment of the present invention.

Fig. 15 (a) is a schematic chart showing the fundamental vibration modes of a conventional piezoelectric actuator.

Fig. 15 (b) is a frequency response characteristics chart for above.

Fig. 16 (a) is a schematic chart showing the fundamental vibration modes of the piezoelectric actuator in a preferred embodiment of the present invention.

Fig. 16 (b) is a frequency response characteristics chart for above.

Fig. 17 is a plan view of the flexure on which are pasted the piezoelectric actuator elements in other preferred embodiment of the present invention.

Fig. 18 is a perspective view of the disc drive in a preferred embodiment of the present invention.

[Description of the Reference Numerals and Signs]

1: Magnetic head (Head element)

2: Slider

2a, 2b, 2c, 2d: Terminal

2e: Air bearing surface

3: Flexure substrate

3a: Slider holder

3b: Projection

4: Load beam

4a: Base end portion

4b: Neck portion

4c: Beam portion

4d: Opening

4e: Plate spring

4f: Regulating portion

4g: Dimple

5: Base plate

6: Head wiring pattern

6a, 6b, 6c, 6d: Wiring

7, 54: Flexure

7x: Slider mounting portion

7y: External connecting terminal holder

8a, 8b: Thin film holder

8c: Flexible substrate

9a, 9b, 9c: Thin film piezoelectric element driving wire

9d: Ground wiring

10: Piezoelectric actuator element

10a: First piezoelectric element unit

10b: Second piezoelectric element unit

11a: First thin film piezoelectric body

11b: Second thin film piezoelectric body

12a: First electrode metal film

12b: Second electrode metal film

12c: Third electrode metal film

12d: Fourth electrode metal film

13: Adhesive

14: Coating resin

14a: Connector

16: Bonded wire

17: Grounding metal film

19a, 19b: Hinge portion

30: slit

40: Coupling portion

41: Wiring coupling portion

50: Disc

51: Spindle

52: Head actuator

53: Head slider

54: Flexure

55: Arm

56: Bearing

57: Singing means

58: Flat coil

59: Arrow mark

100: Head supporting mechanism

[Name of the Document]   Abstract

[Abstract]

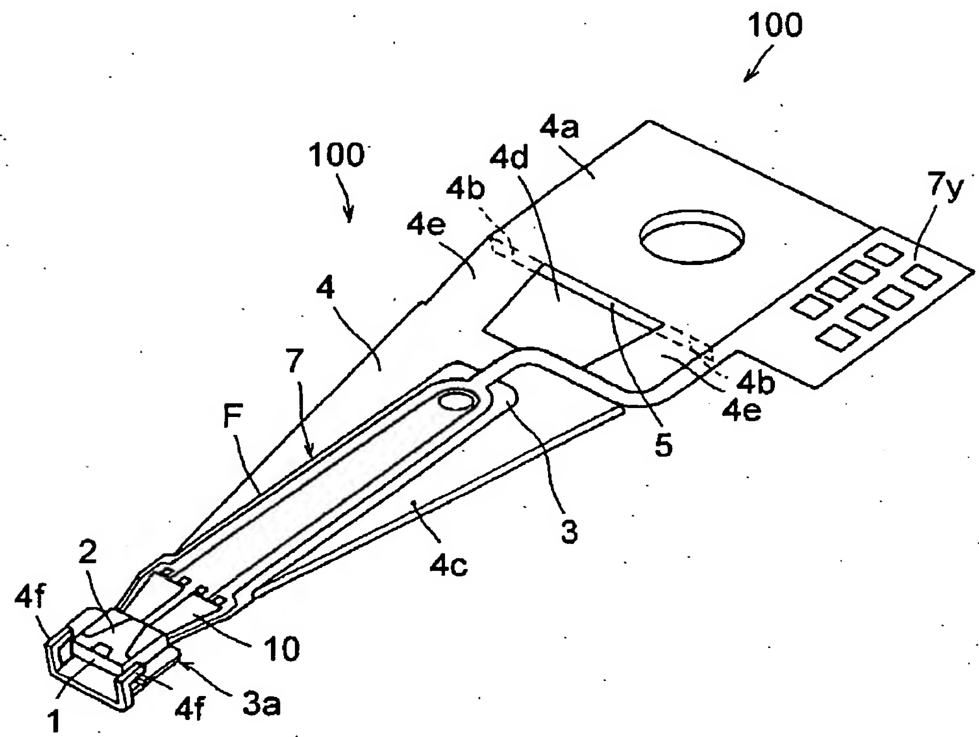
[Object] Provide a piezoelectric actuator not producing bending resonance generated at extension/contraction of the piezoelectric actuator, and a disc drive using the same, by reinforcing the bending mode of piezoelectric actuator.

[Means to Solve the Problems] Comprise first piezoelectric element unit 10a and second piezoelectric element unit 10b displaced with extension/contraction by application of voltage, and coupling portion 40 for coupling first piezoelectric element unit 10a and second piezoelectric element unit 10b, at the position of the loop of the primary bending mode of the first piezoelectric element unit 10a and the second piezoelectric element unit 10b respectively.

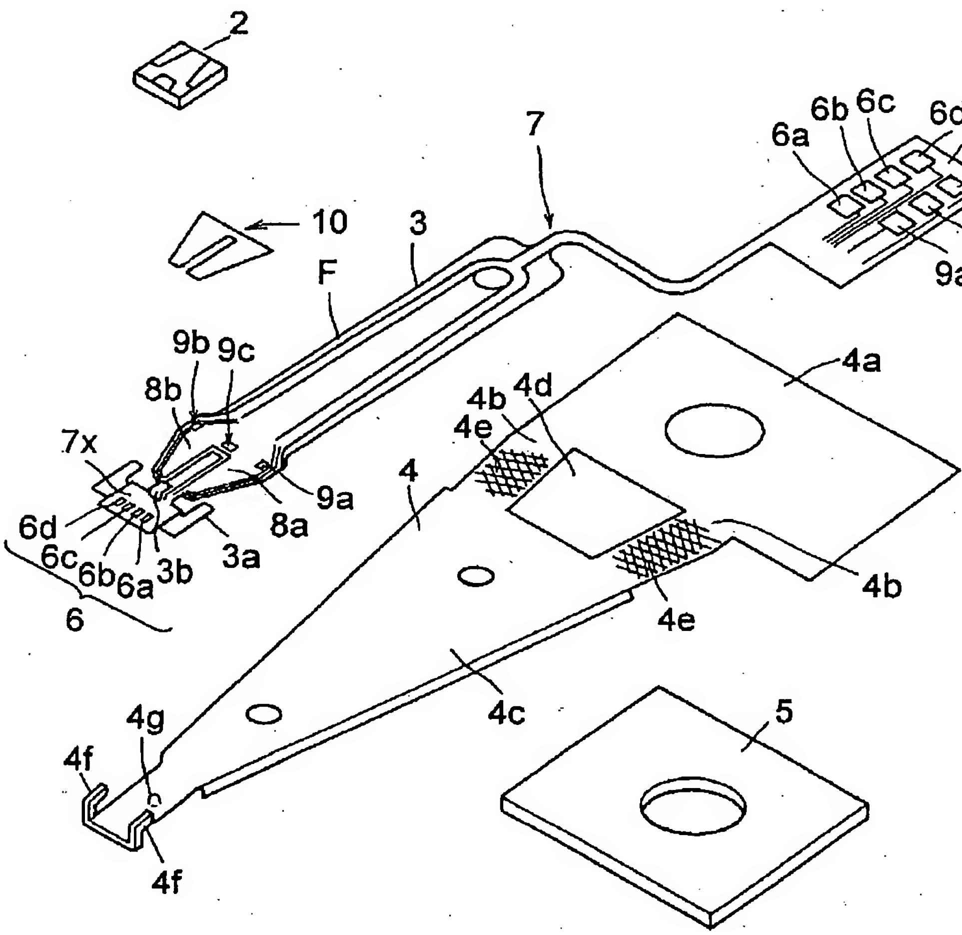
[Selected Drawing]   Fig. 10

[Name of the Document] Drawing

[Fig. 1]



[Fig. 2]


2
10
3
7
F
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6b
6c
6d
7y
9c
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8b
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6a
3b
3a
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4e
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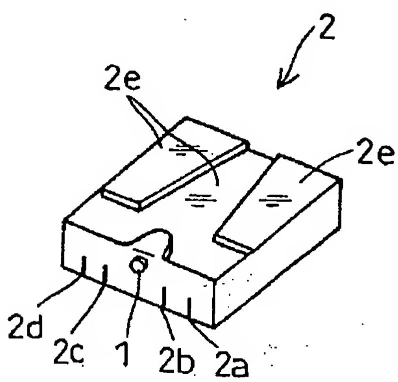
4e
4c
4g
4f
4f
5

[Fig. 3]


2
2e
2e
2d
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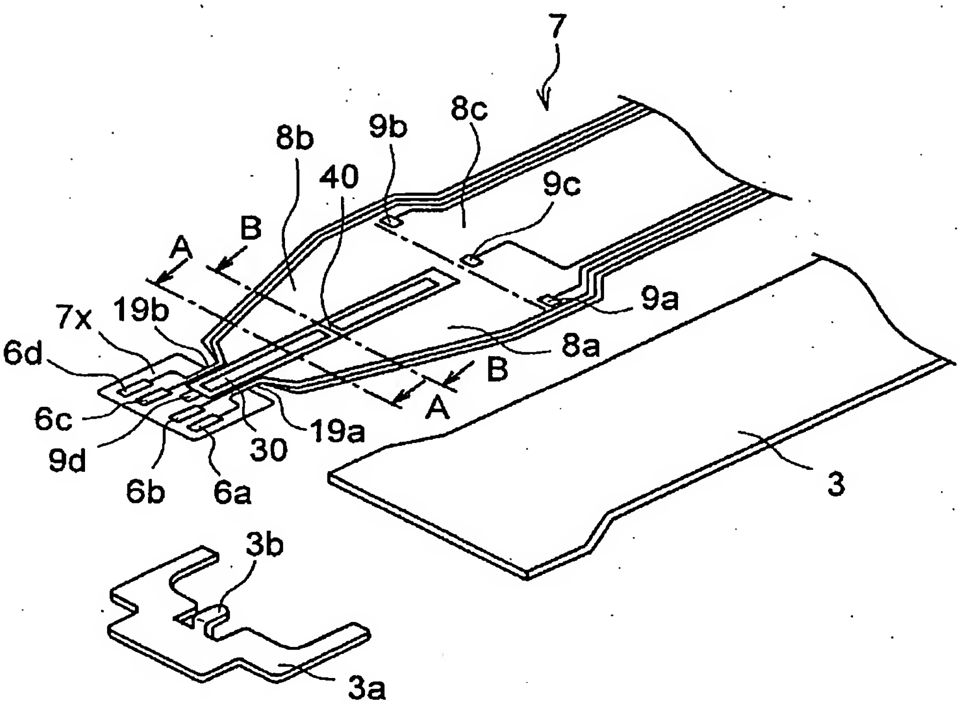
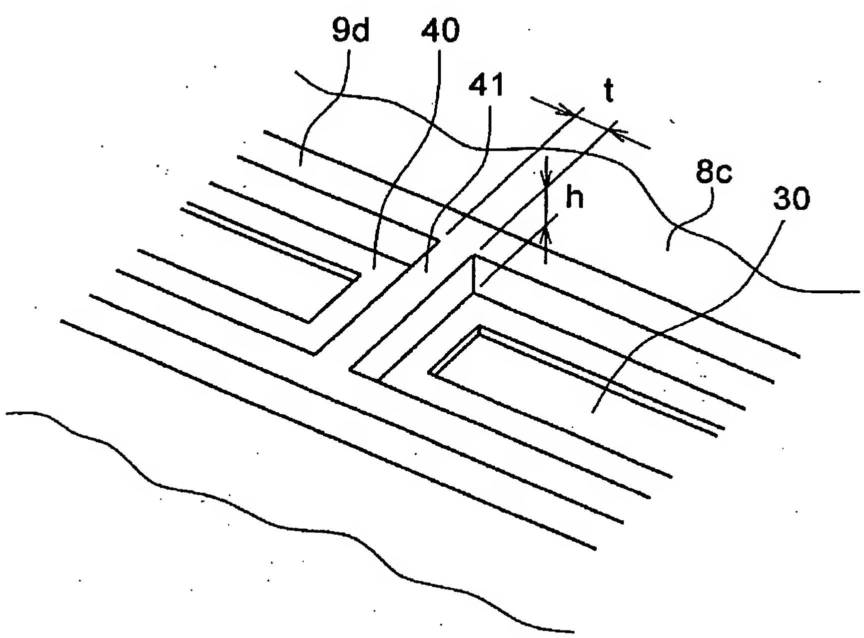
1
2b
2a

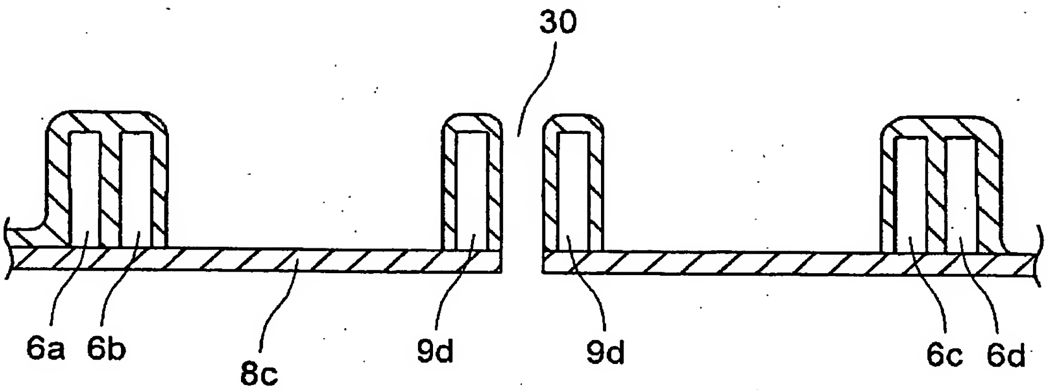
[Fig. 4]


7
8c
9b
8b
40
9c
A
B
9a
7x
19b
6d
8a
B
A
6c
19a
30
9d
3
6b
6a
3b
3a

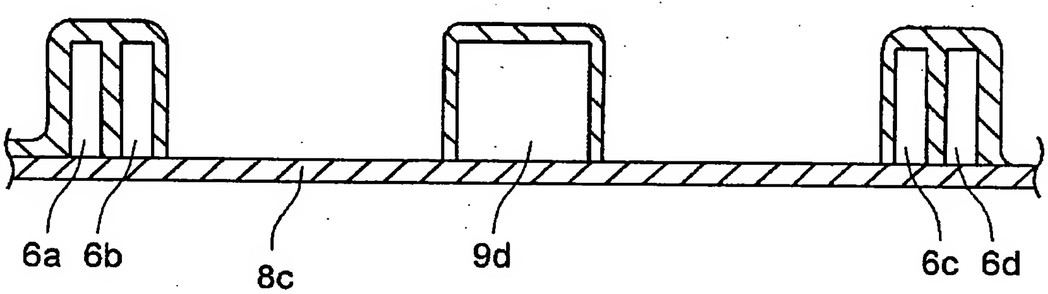
[Fig. 5]


9d
40
41
t
h
8c
30

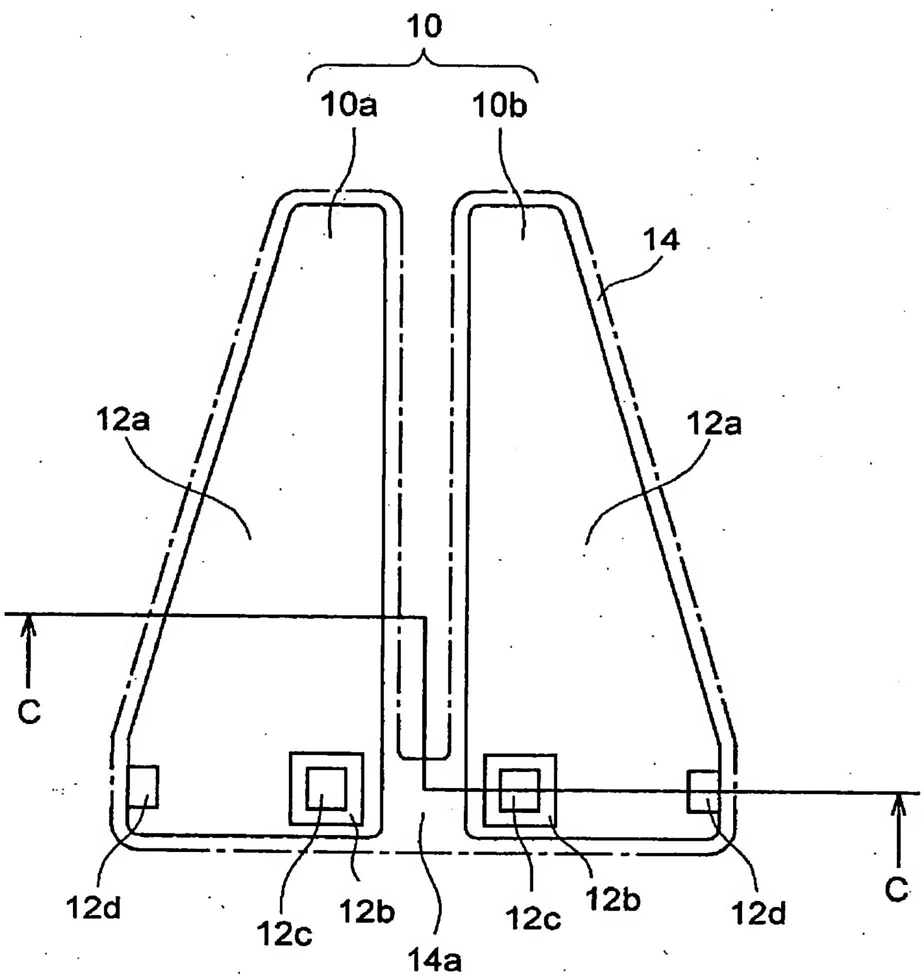
[Fig. 6]



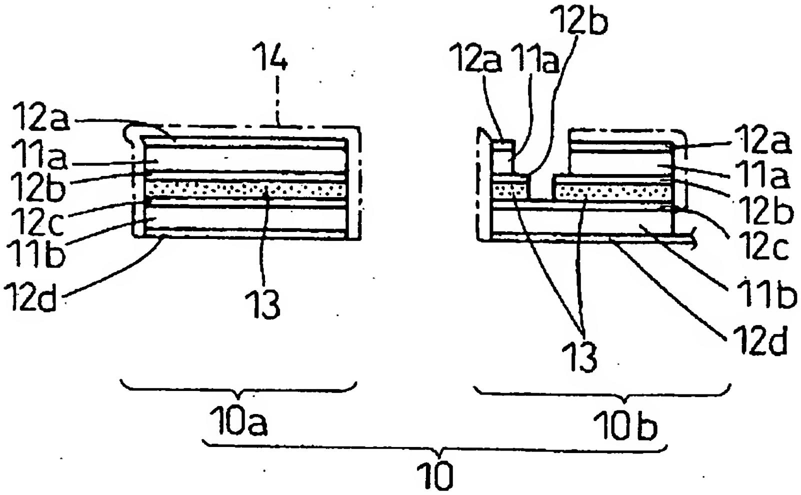
[Fig. 7]



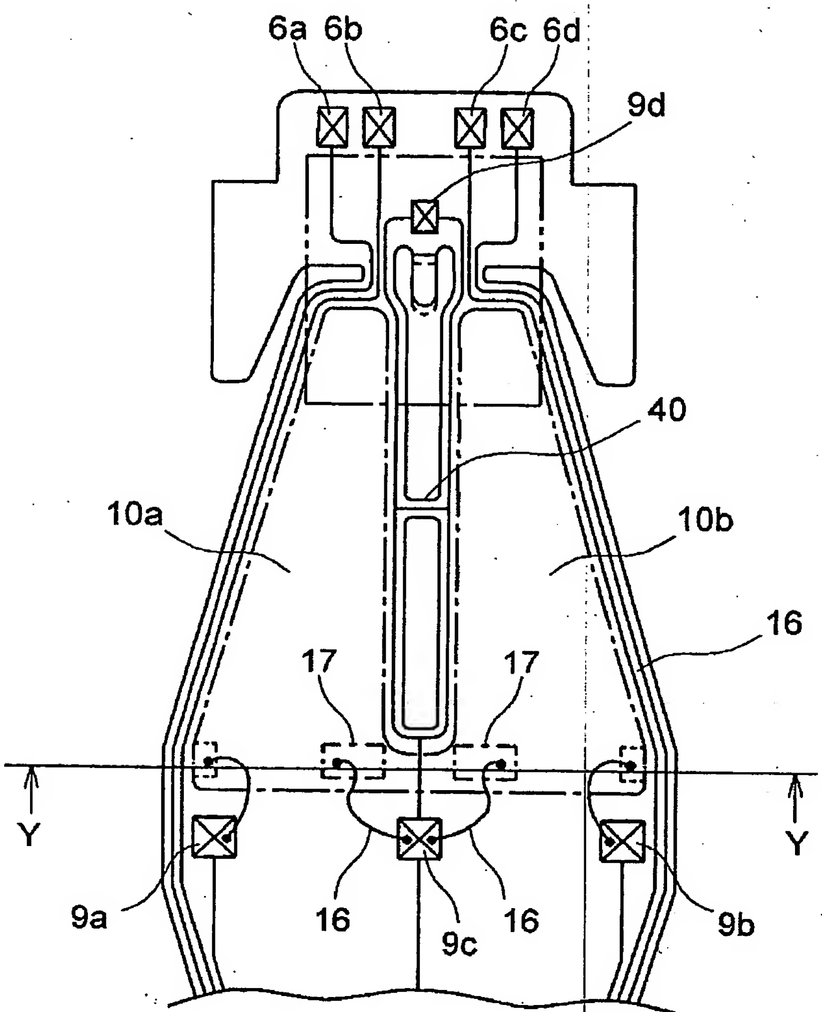
[Fig. 8]



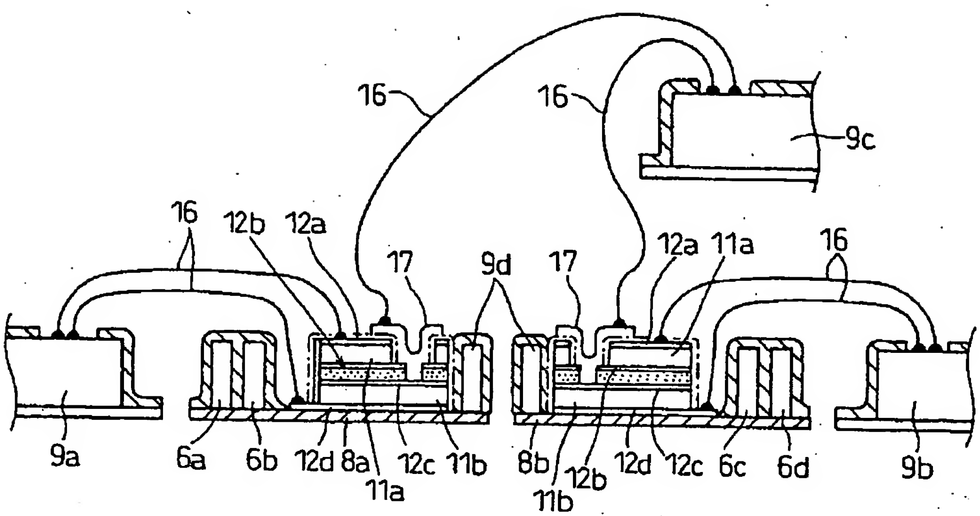
[Fig. 9]


14
12a
11a
12b
12c
11b
12d
13
12b
12a 11a
12a
11a
12b
12c
11b
12d
13
10a
10b
10

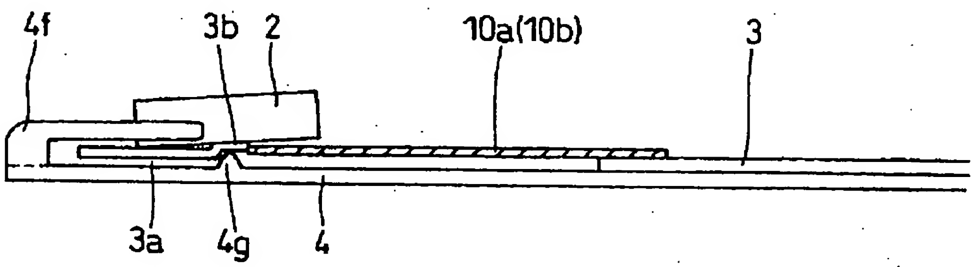
[Fig. 10]



[Fig. 11]

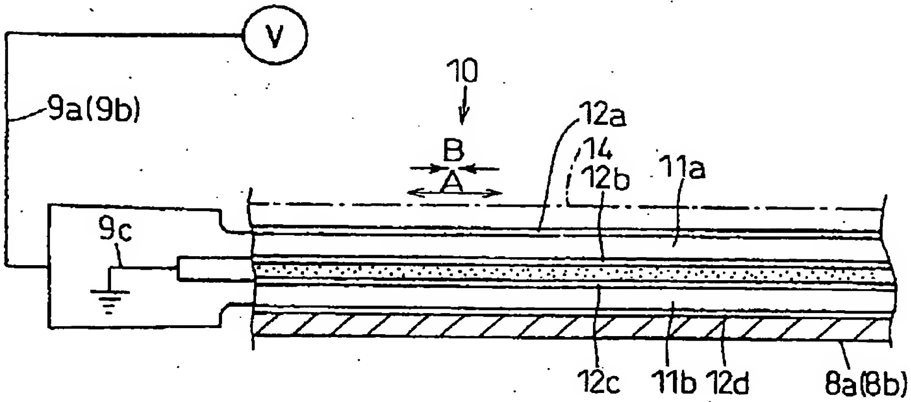

16
16
9c
16
12b
12a
17
9d
17
12a
11a
16
9a
6a
6b
12d
8a
11a
12c
11b
8b
12b
11b
12d
12c
6c
6d
9b

[Fig. 12]

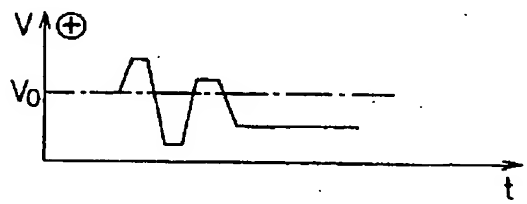

4f
3b
2
10a(10b)
3
3a
4g
4

[Fig. 13]

(a)

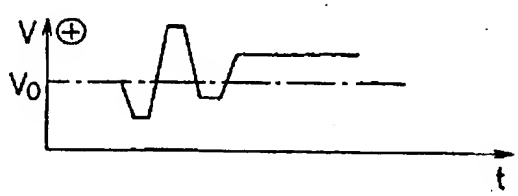


(b)



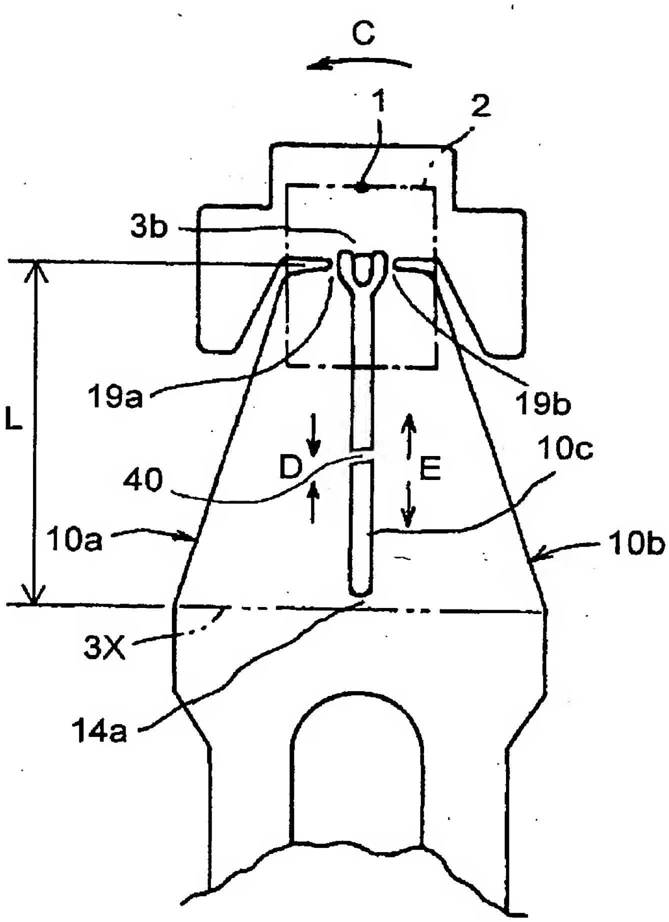
Applied voltage of thin film piezoelectric element driving wire 9a

(c)



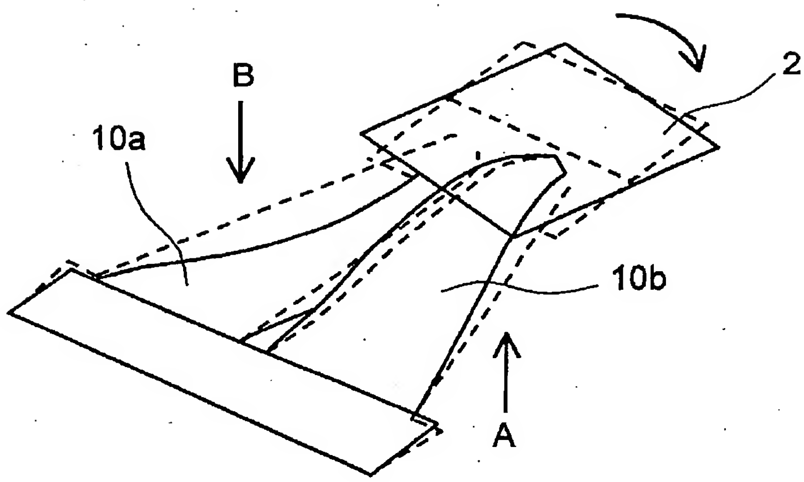
Applied voltage of thin film piezoelectric element driving wire 9b

[Fig. 14]



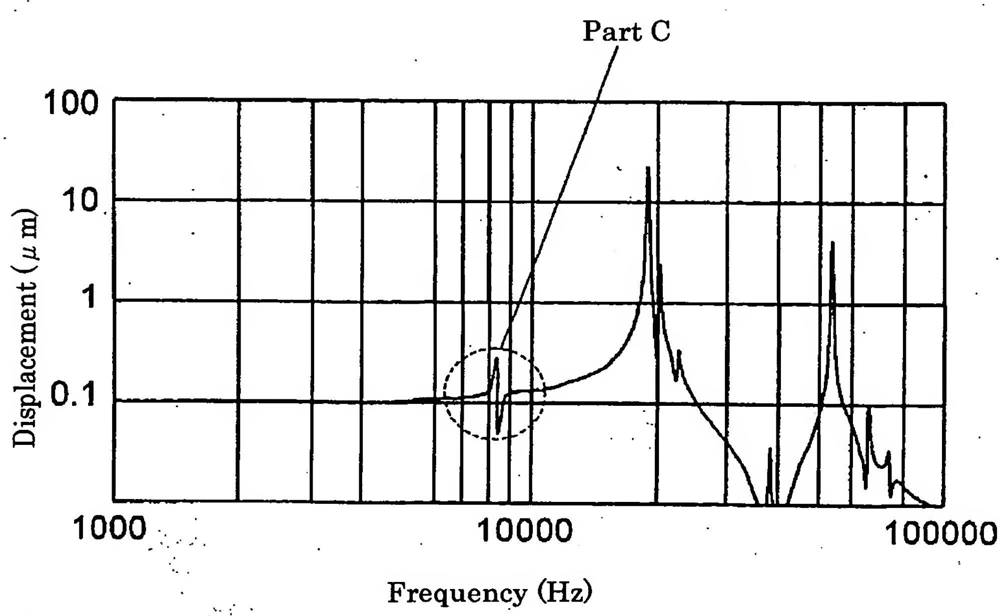
[Fig. 15]

(a)



B
10a
2
10b
A

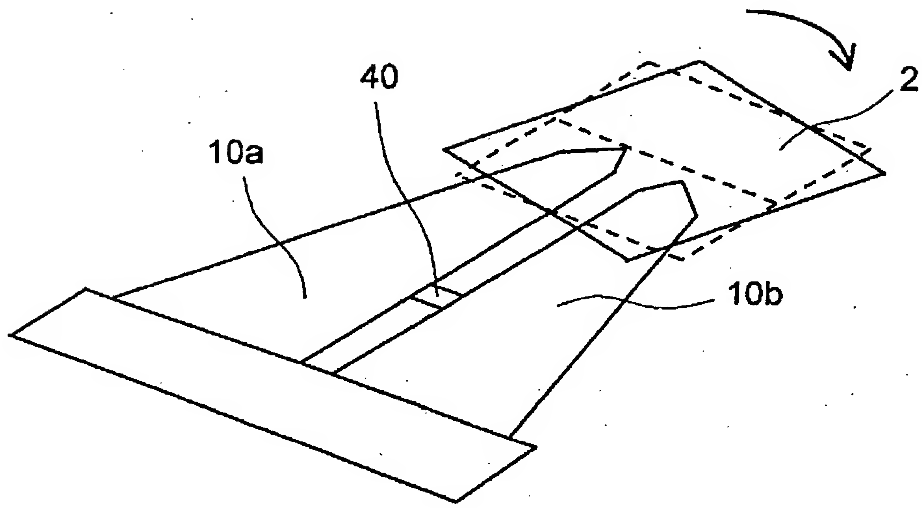
(b)



Part C
100
10
1
0.1
Displacement (μm)
1000
10000
100000
Frequency (Hz)

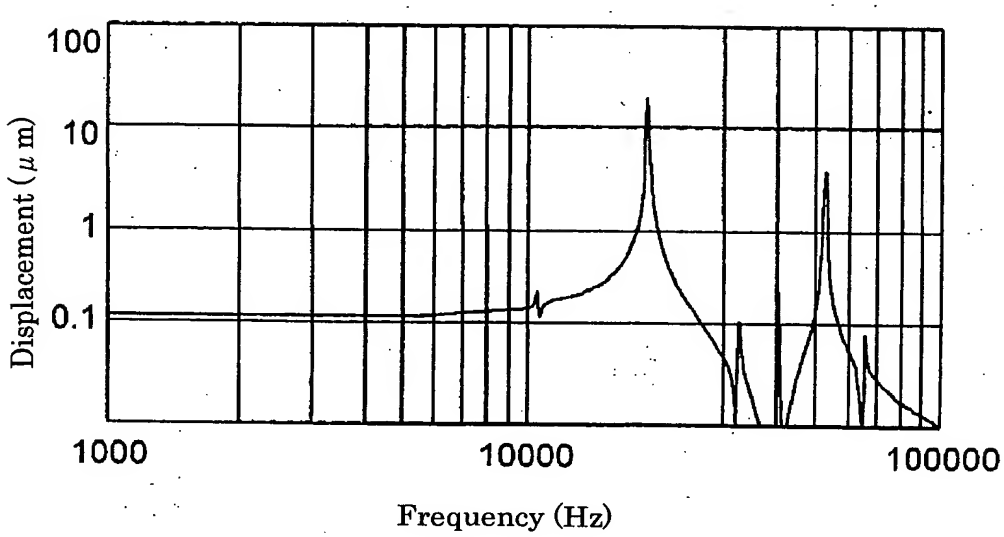
[Fig. 16]

(a)



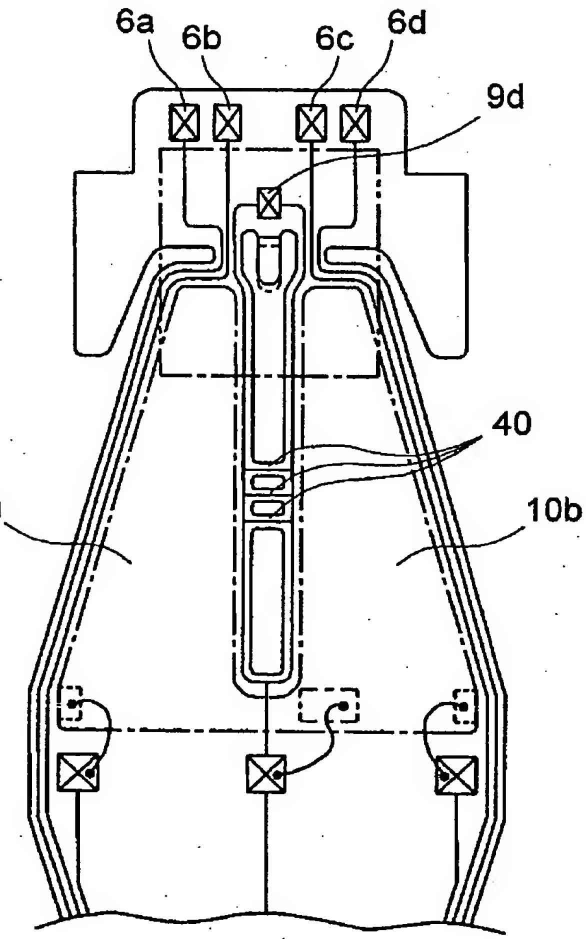
40
10a
2
10b

(b)



100
10
1
0.1
Displacement (μm)
1000
10000
100000
Frequency (Hz)

[Fig. 17]



[Fig. 18]